Evaluation of Innovative Methane Detection Technologies

Guidance for Evaluating Methane Detection Technologies for a Variety of Applications, including Regulatory Requirements

www.itrcweb.org

Outline

1. What Is ITRC?
2. Context & Challenge for Methane Detection Technology Evaluation
3. Characterization of Oil & Gas Emissions and Sources
4. Methane & Leak Detection Regulations
5. Technologies Overview
6. Evaluation of Technologies
7. Lessons Learned
8. Example Evaluation Scenarios
9. Stakeholder Perspectives

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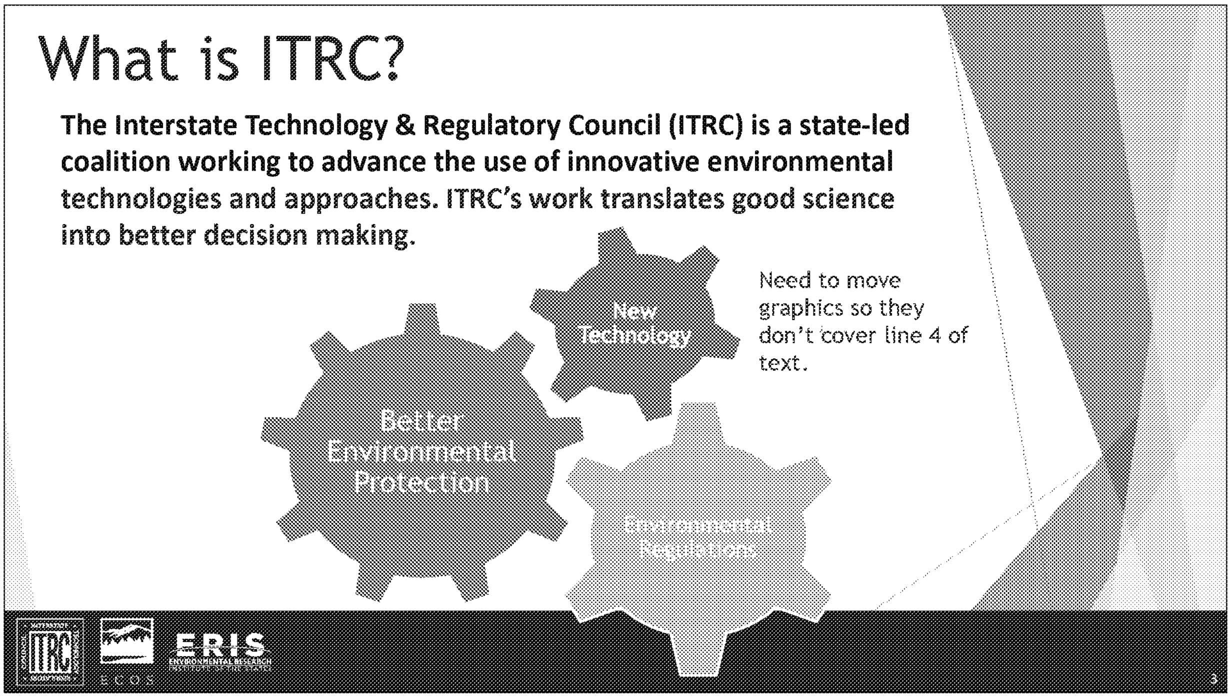
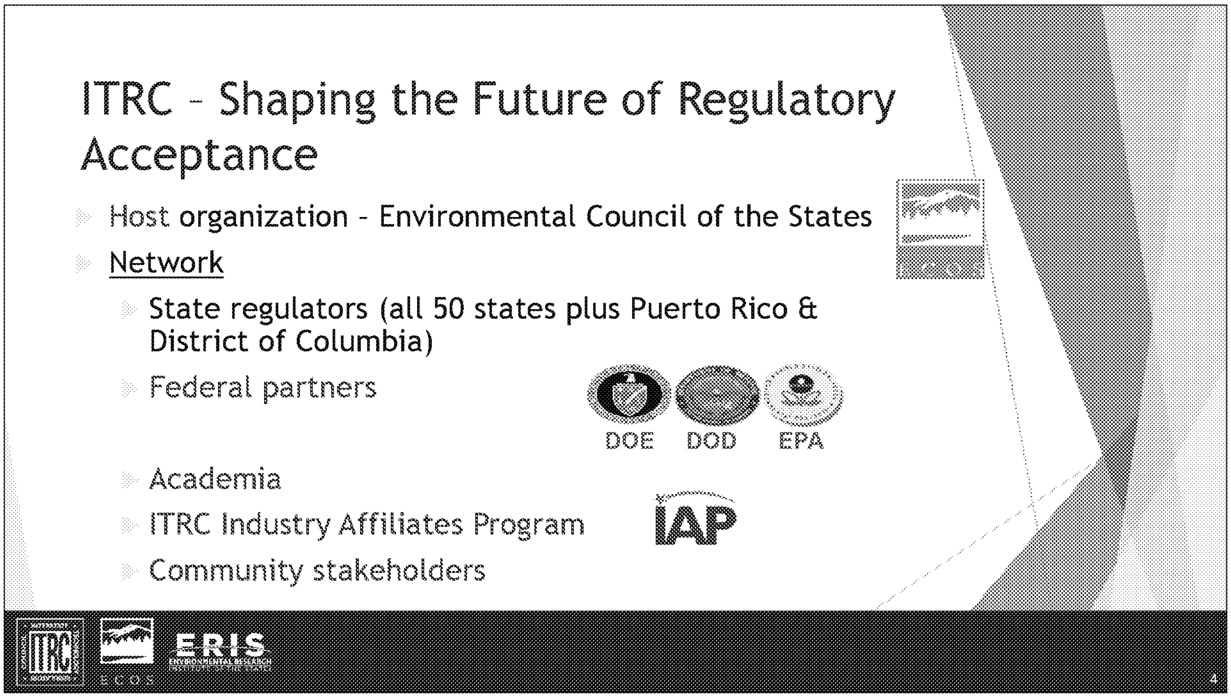


ITRC is a 501(c)3 program of the Environmental Council of the States (ECOS) and is based in Washington DC. ITRC provides information resources on technically-sound innovative solutions to environmental challenges. Part of ITRC's mission is to foster integration of new beneficial technical developments within existing regulatory frameworks.

ITRC is a state-led coalition of state regulators, industry experts, public/tribal stakeholders, academia, and federal partners that works to achieve regulatory acceptance of innovative environmental technologies and approaches. ITRC consists of 50 states (and the District of Columbia and Puerto Rico) and works to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC resources expedite quality decision making, while protecting human health and the environment.



Comment: ITRC "about" section from their webpage does not list Puerto Rico as a member?
The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition of regulators, industry experts, citizen stakeholders, academia and federal partners that work to achieve regulatory acceptance of environmental technologies and innovative approaches. ITRC consists of all 50 states (and Puerto Rico and the District of Columbia) that work to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC brings together a diverse mix of environmental experts and stakeholders from both the public and private sectors to broaden and deepen technical knowledge and advance the regulatory acceptance of environmental technologies. Together, we're building the environmental community's ability to expedite quality decision making while protecting human health and the environment. With our network of organizations and individuals throughout the environmental community, ITRC is a unique catalyst for dialogue between regulators and the regulated community.
For a state to be a member of ITRC their environmental agency must designate a State Point of Contact. To find out who your State POC is check out the "contacts" section at www.itrcweb.org. Also, click on "membership" to learn how you can become a member of an ITRC Technical Team.

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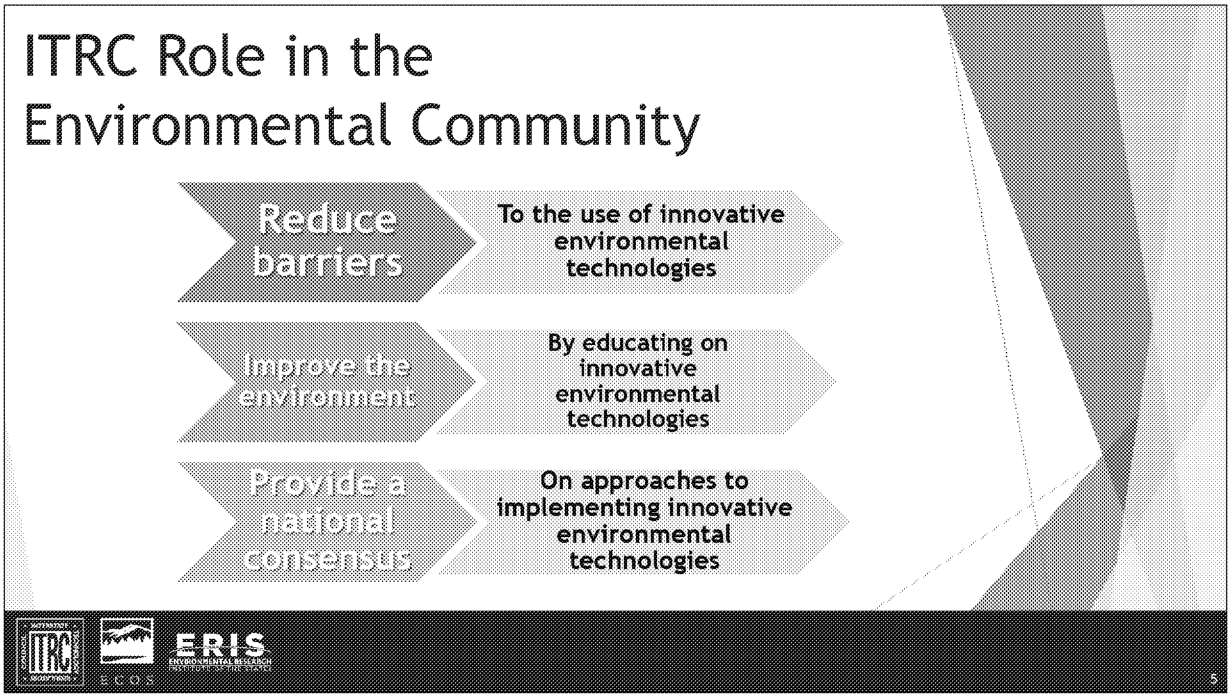
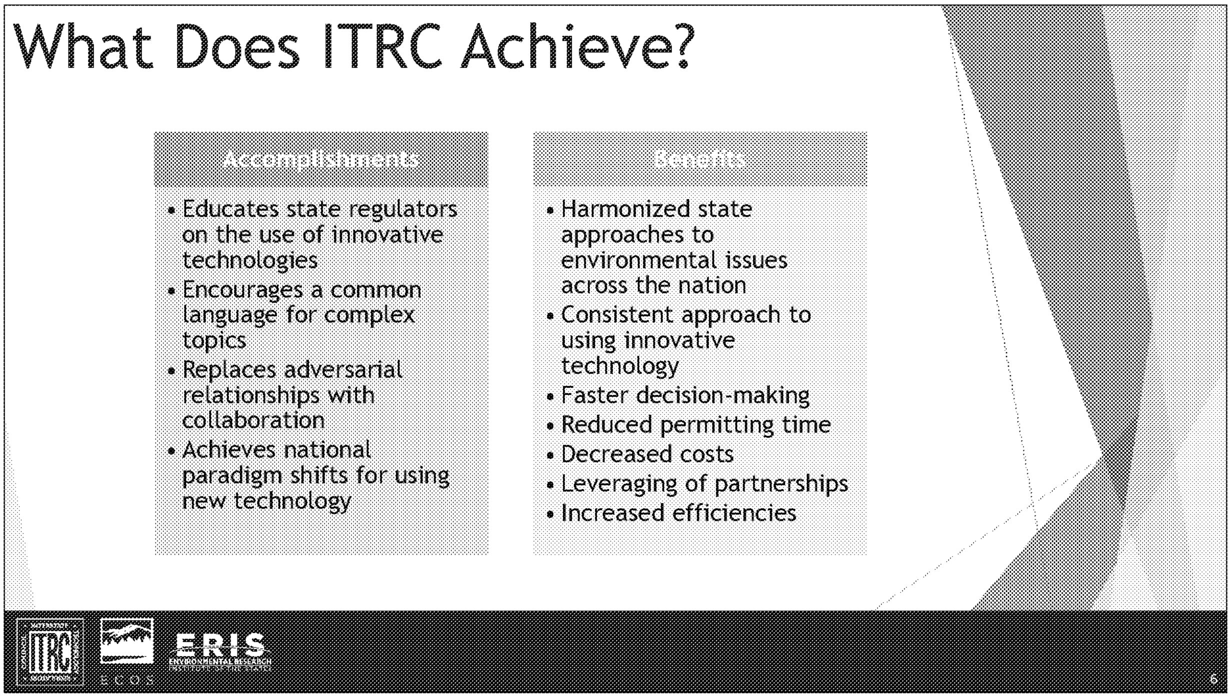


Why are innovative environmental technologies/approaches important? Innovative environmental technologies/approaches are (1) typically more cost-effective and efficient than traditional approaches and (2) can provide a solution for a problem where no solution previously existed. Barriers exist to using innovative environmental technologies, including (1) lack of understanding or trust in the benefits of the innovative technology; (2) different sets of procedures and/or data requirements among states; (3) institutional resistance to change; and
(4) regulatory inflexibility or pre-specified approaches.

ITRC works to break down barriers by (1) increasing state regulators' understanding and confidence in innovative technologies/approaches; (2) producing guidance documents and training that are used by environmental professionals across the country to increase regulatory consistency from state-to-state; (3) fostering integration of new technical developments within existing regulations; (4) creating networks of technical experts for use by states when making decisions on innovative environmental technologies/approaches; (5) showing the cost and time savings that can be achieved with innovative environmental technologies/approaches.



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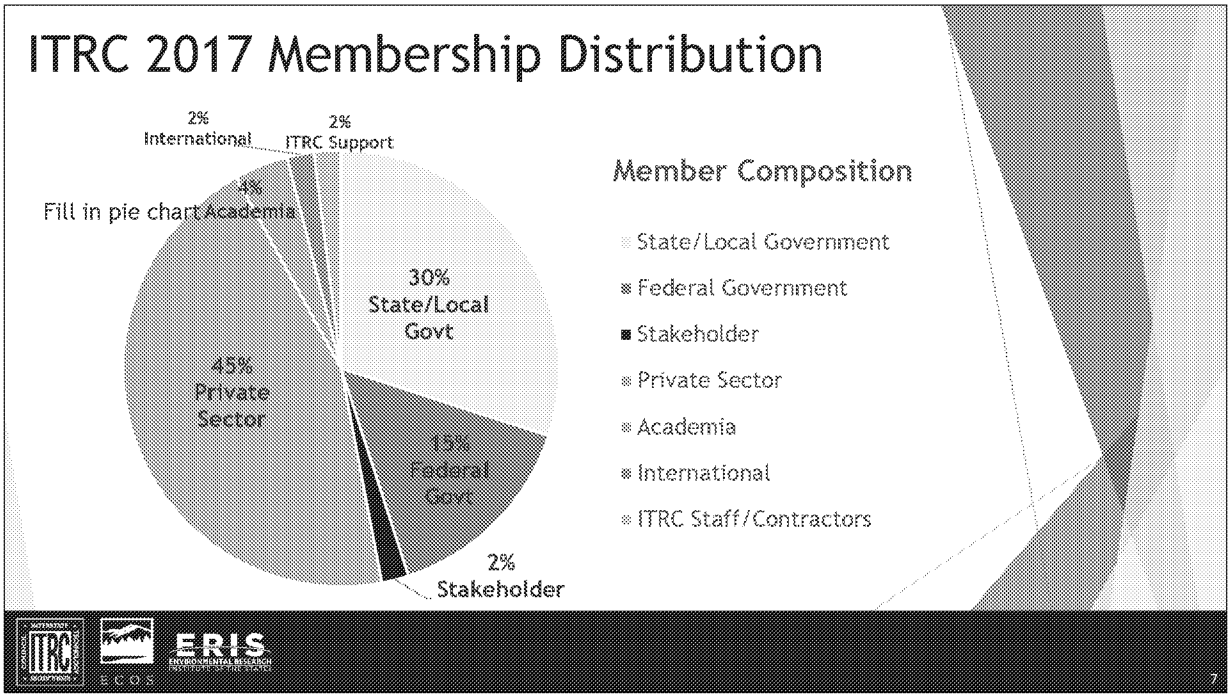
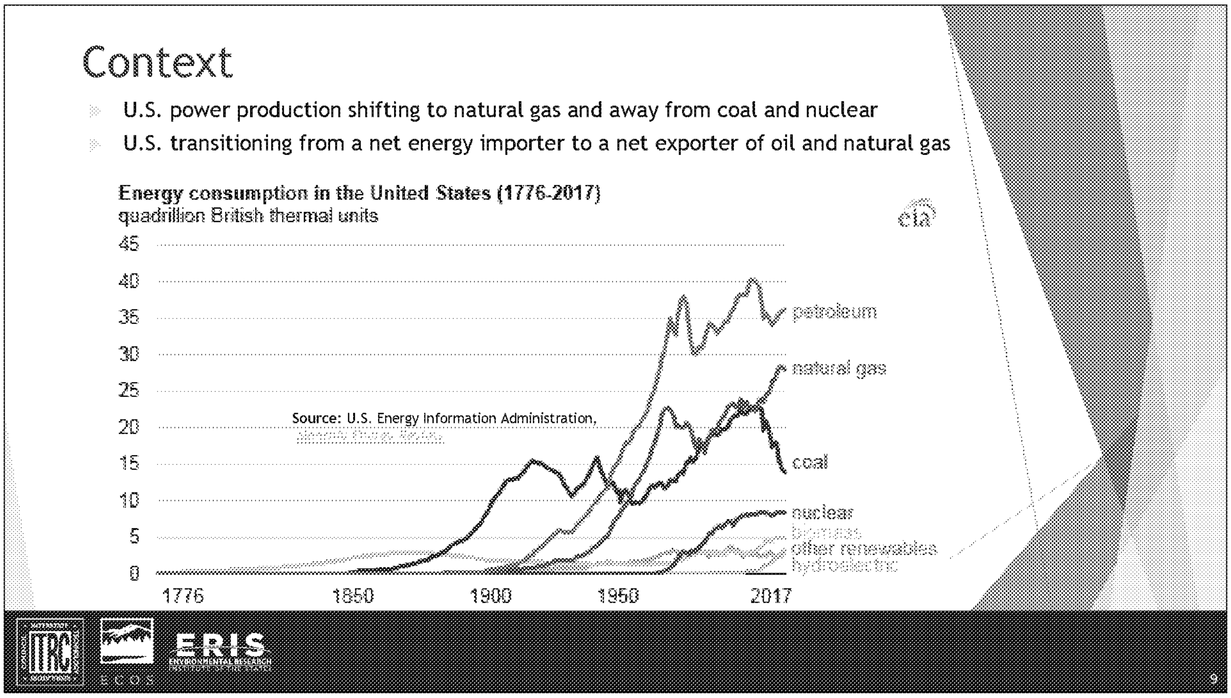


Over 900 members total, 45% private sector, 45% government

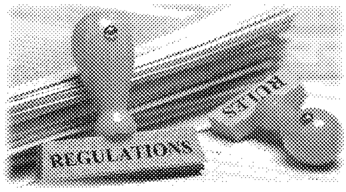
Evaluation of Innovative Methane Detection Technologies

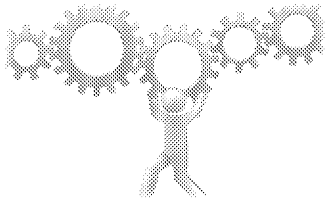
- 60+ individuals representing State, Federal and International Regulators, Private Industry, Public Stakeholders, Academia and Others collaborated for over 2 years to produce technical-regulatory guidance document, which was published in September 2018 (ITRCweb.org)
- Provides a centralized reference for oil & gas methane emission sources, leak monitoring regulations, detection technologies, evaluation guidelines and principles, and relevant case studies summaries/links



So, not only are we producing natural gas for U.S. needs, we are producing enough to send out of country.
In 2017, the US exported 0.3 billion ft3 of natural gas more than what the US imported.

Context





- Federal, state and international regulations addressing methane from oil and gas
- New detection technologies and applications being developed and introduced into the market
- No standard methodology or guidelines to evaluate performance and equivalence of new or innovative methane detection technologies to existing approved technologies or methods

June 3, 2016: NSPS OOOOa final published (81 FR 35824) - Footer
Add State regs & Canada…, BLM… etc…
Mention the Kyoto Protocol – 10 years ago but starting point for Canadian Regs….

The Challenge…

- How to evaluate and compare various methane/leak detection and measurement technologies?
- What are the important questions and considerations to help meet specific regulatory requirements or needs for various segments of the oil and gas supply chain?
- How does it all tie together?

(Emission Sources + Regulations + Technologies + Evaluation Methods)

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Based on the context which was reviewed on the previous slides, there is one key challenge…James Jarrett had suggestions in his pdf comments. Varied and diverse applications

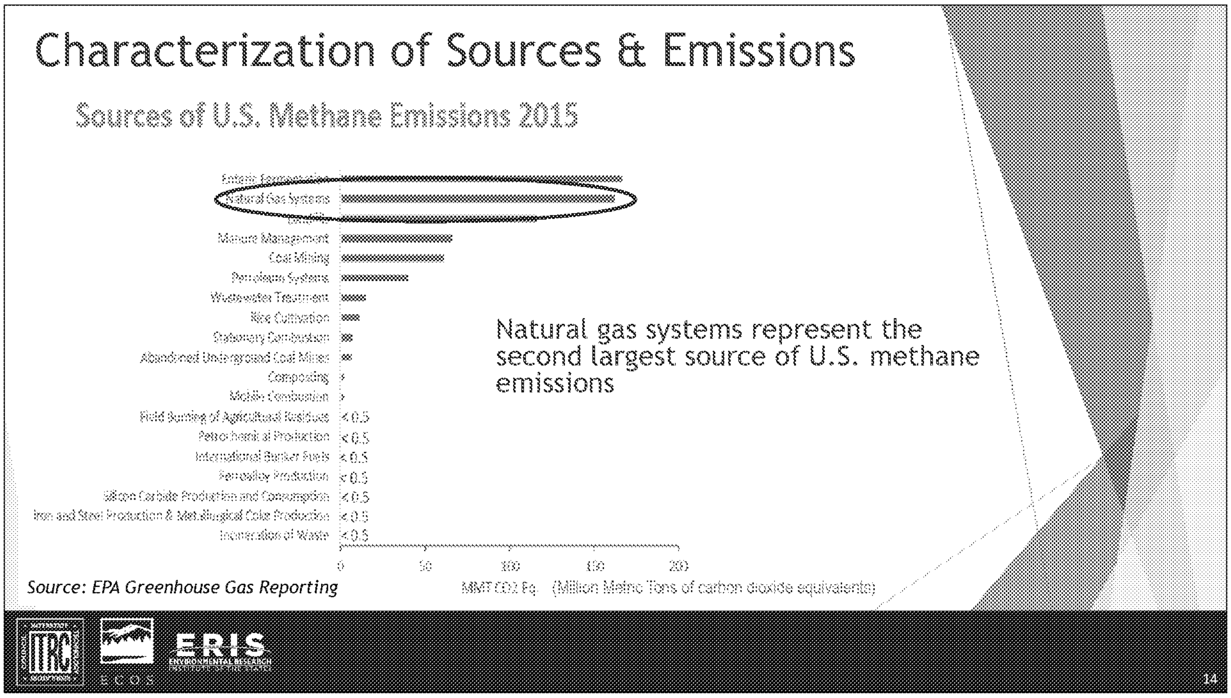
The Resource: Evaluation of Innovative Methane Detection Technology Tech-Reg Document

- Characterization of various methane emission sources along the entire oil and gas supply chain
- Summary of existing and proposed methane and leak detection regulations for each segment of the oil and gas supply chain, including regulations that allow for approval of alternative detection technologies
- Identification of regulatory barriers and opportunities to the use of new or innovative methane detection technologies

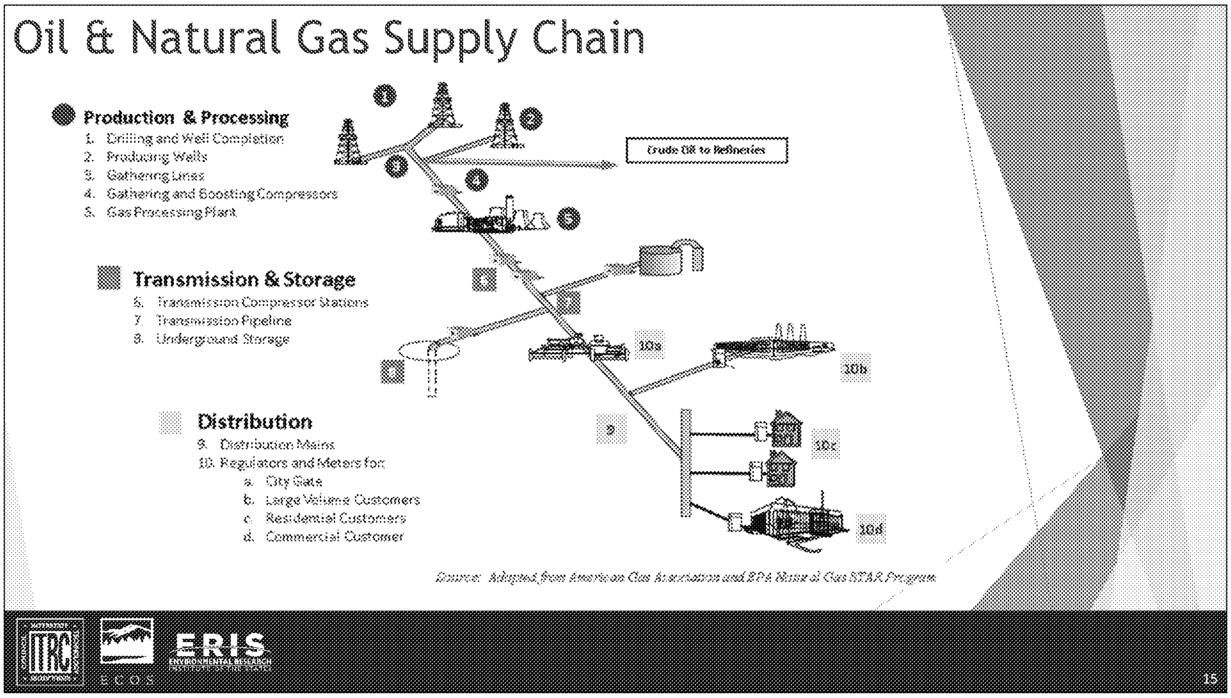
The ITRC solution to this challenge is to provide a resource for evaluation.

The Resource: Evaluation of Innovative Methane Detection Technology Tech-Reg Document

- Overview of existing and emerging methane detection technologies and their applications
- Guidance regarding performance characteristics and parameters to consider in technology evaluation
- Provides a starting point and framework for evaluation of detection technologies



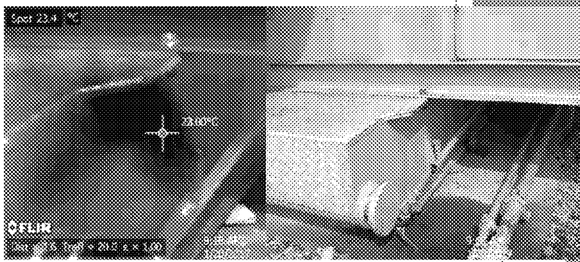
Why did we focus on the oil and natural gas sector?
Evaluation of EPA data shows where the low-hanging fruit is.



To best understand how methane detection technology will apply, it's often helpful to characterize the industry and the ITRC resource does go into some detail.
Here we show why this sector needs different types of technology, there are a multitude of sources with differing emission types… continuous, intermittent, large & small releases…

Sources of Emission Releases

- Non-routine engineered
  - Fugitive equipment leaks
  - Emergency pressure relief
  - Engine crankcase vents
- Intentional engineered
  - Venting or flaring activities
  - Pneumatic controllers/devices
  - Equipment depressurization & blowdown for maintenance
- Non-engineered
  - Improperly sized, maintained or functioning emission control systems (vapor collection systems, catalytic converters, flame failures/incomplete combustion)
  - Accidental releases; operator error



In addition to characterizing the supply chain, it's important to characterize the types of emission releases associated with this sector. The very breadth of processes required for the natural gas and oil supply chain demonstrates the need for varied leak detection technologies. Leak sources contain different compositions, frequencies, and flowrates requiring the selection of appropriate leak detection technology.
Image: Distance piece drain vent from single compressor. Note sprayed and pooled oil underneath vent.

Different Types of Methane Regulations & Oversight

- Environmental Protection & Resource Conservation
  - Environmental Protection Agency (EPA)
  - Bureau of Land Management (BLM)
  - State and Tribal Environmental and Oil & Gas Oversight Agencies
- Operational & Public Safety
  - Pipeline and Hazardous Materials Safety Administration (PHMSA) of the U.S. Department of Transportation (DOT)
- Safety and Just and Fair Utility Rates
  - State Public Utility Commissions

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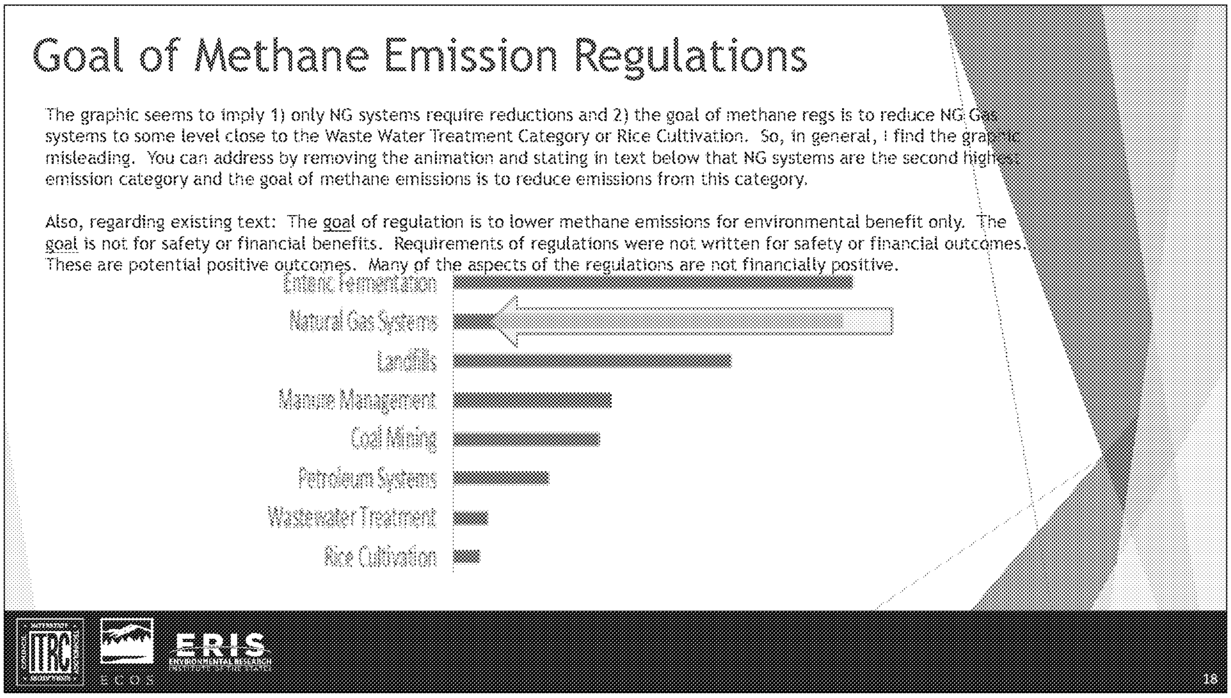
Environmental: Federal & state agencies overseeing fugitive emissions or equipment leaks from production, processing, and transmission & storage facilities.
Operational & Public Safety: PHMSA oversees pipelines natural gas systems (including leak surveys) from distribution, transmission, storage, and LNG)
Safety & Just & Fair Utility Rates: State Public Utility Commissions also regulate leak surveys, infrastructure upgrades, and economic ratemaking related to natural gas distribution and intrastate pipelines and storage facilities.
Add to notes – regs flow from supply chain (Tim)

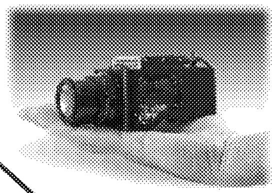


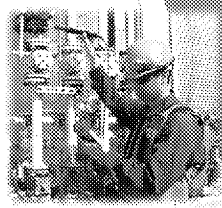
Click again for animation lowering the methane emissions from NG bar.

The Goal of the regulation is to lower methane emissions for environmental, safety and financial benefits…
Main objective for air quality regulations - to protect of human health and environment while balancing cost and benefits, enforceability, and community concerns

Regulations & Allowable Technologies

- Environmental Protection & Resource Conservation
  - EPA Method 21
  - Optical Gas Imaging (OGI)
  - Alternative Methods/Technologies
    - EPA - NSPS OOOOa
    - BLM - Waste Prevention Rule
    - State Agencies - CO, PA, CA* (*transmission/distribution/storage only)
    - Canada - Federal & Provincial (Alberta)
- Operational & Public Safety
  - "Leak detector equipment" (any equipment capable of detecting all leaks in gas distribution and transmission systems) - PHMSA





Is this the correct heading for this category. Does not seem to relate to all of the sub bullets

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The Regulations portion of the guidance document describes the generally approved leak detection methods and goes on to describe how some states are allowing for alternative methods.
Method 21 is EPA procedure (should reference) to detect VOC leaks from process equipment using a portable detecting instrument
Detector types that may meet this requirement include, but are not limited to, catalytic oxidation, flame ionization, infrared absorption, and photoionization.
Easily enforceable concentration standards, (but can be time- and labor-intensive). Every valve must be scanned?
Commercial enterprises have produced new detection techniques, such as OGI
Make detection possible by display on a screen, allowing visualization of a gas plume that is otherwise invisible to the naked eye
OGI offers an approach to monitor hard-to-reach or unsafe equipment, but has higher detection limit and lacks a formal regulatory written monitoring protocol

Regulatory Barriers & Considerations

- Pathway to approval for alternative technologies
  - Regulatory allowance for alternative technologies
  - Clearly defined review criteria & approval requirements
- Regulatory Considerations
  - Commercial availability & maturity of technology
  - Leak detection program vs. technology
  - Capabilities, reliabilities and limitations of technology or program
  - Equivalency criteria
  - Enforceability
  - Alternative technology pilot program

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Technologies Summary (Classification Scheme)

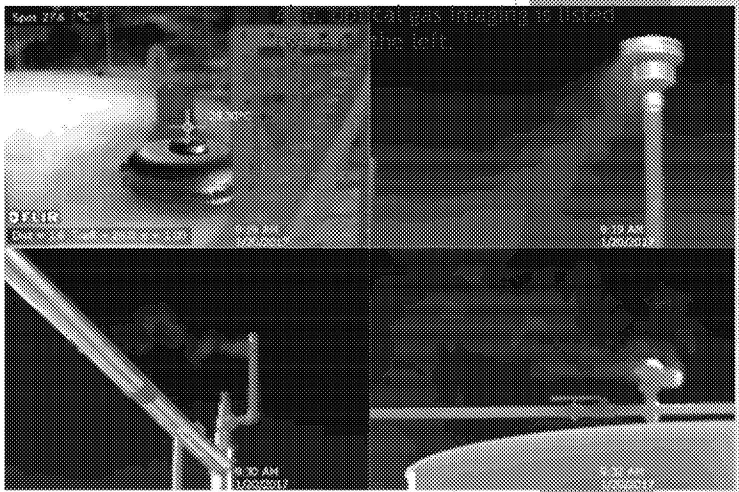
Consideration	Response
Primary Data Type	Quantitative vs. Qualitative
Result Type	Yes/No vs. Value
Detection Range	% or ppm or grams/hour, etc.
Measurement Temporal Distribution	Seconds, Minutes, etc.
Size of Device	Small, Handheld, Large,
Deployment Method	Fixed, Walking, Vehicle Path, etc.
Environmental Limitations	Humidity, Temp, Contaminants, etc.
Maturity	Mature vs. Developing
Specificity to Methane	Nonspecific/Specific & Low/High

The guidance contains tables which assess different considerations depending on the approach needed… here are some…
Use this approach to introduce Method 21 vs OGI.

General Technology Categories

Can you provide other photos other than just infrared FLIR?

Optical Gas Imaging (OGI)
Flame Ionization Detector (FID)
Tunable Diode Laser
High Flow Dilution Sampler
Catalytic Combustion
Metal Oxide
Gas Chromatography (GC)
Mass Spectrometry (MS)
Printed Nanotubes
Tunable Laser (closed path)
Etalon
Optical Gas Imaging
Fourier Transform Infrared (FTIR)



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Bolded are the most readily used

Technology Evaluation

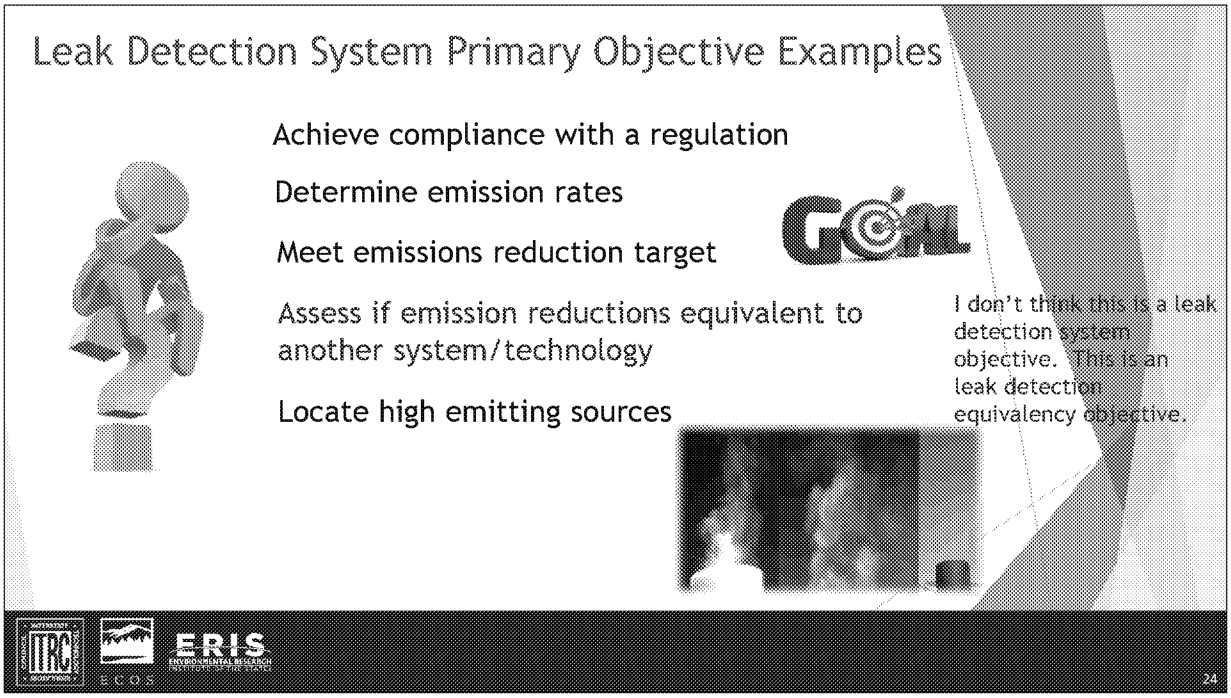
- How to evaluate the performance of new or innovative leak detection systems?
- Primary or ultimate objective is leak or emissions detection but for what purpose or need?
- Clarify and define specific system goals or requirements
  - Evaluation is dependent on a clear understanding of the desired goals or requirements to be achieved
  - Objectives should be agnostic to system technology and platform to expand the number and type of potentially successful systems
  - Develop system objective statement and metrics

I'm not sure I understand this. In an evaluation, the goal should not be to affect the outcome of number of potentially successful systems. One would say that introduces bias.

ECOS

With growing innovation technology, there is concurrent development of multiple approaches for evaluating performance.

Technology vs Methodology - discuss here? Ask David Lyon this section (or Others) - for gut check (makes sense?)
There is an interest in more efficient and effective measurement options.

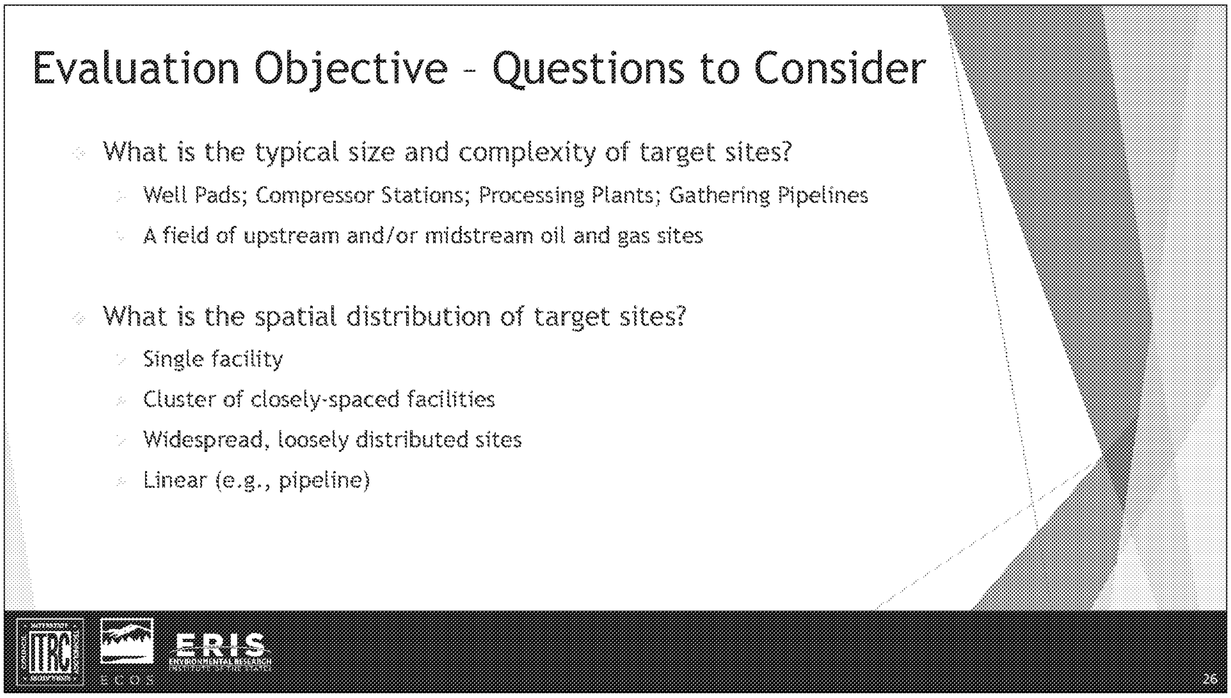


Detect methane concentration above a specific concentration limit or difference from baseline concentration
Detect the presence of emission sources above a specific emission rate
Quantify the emission rate of a site and/or individual sources
Locate fugitive emission sources at a site/sub-site level to increase the efficiency of follow-up, component-level surveys such as OGI
Locate fugitive emission sources at a spatial resolution allowing direct identification of the leaking component
Assess if emission reductions achieve a percentage target
Assess if emission reductions are equivalent to another technology
Achieve compliance with a specific regulation or voluntary program

Technology Evaluation

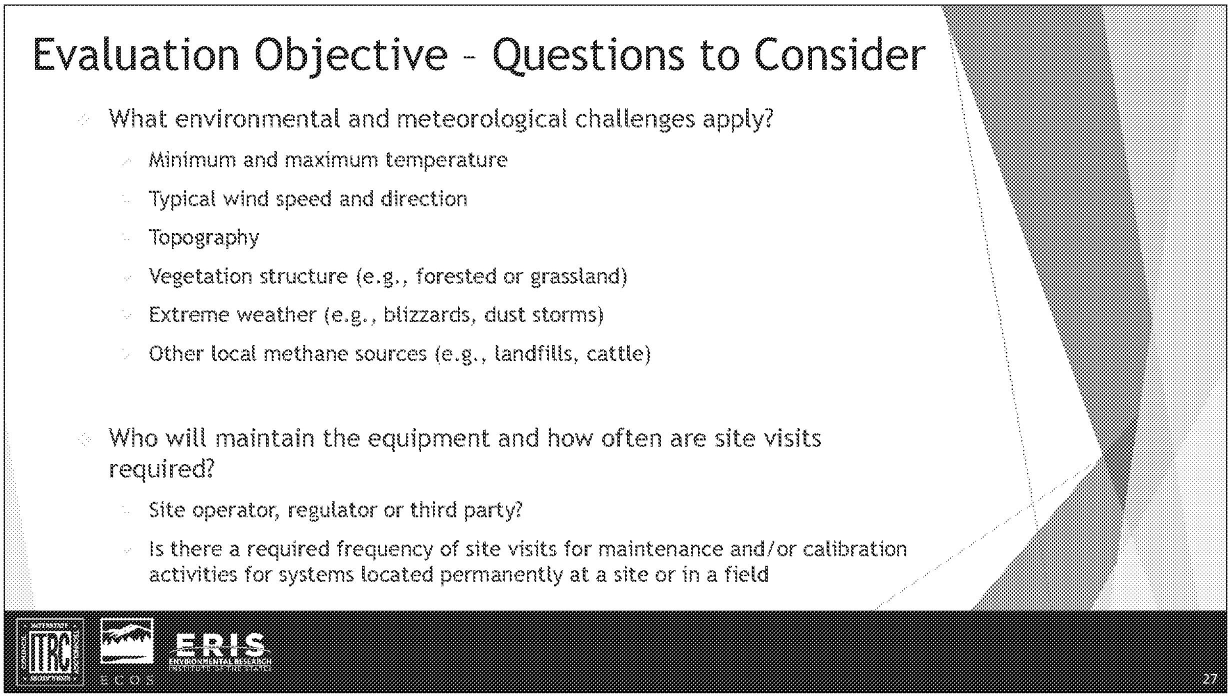
Example primary objective:

Achieve Compliance with a Regulation. The system will detect leaks for repair at well sites/well pads equivalent to or better than that achieved by completing semi-annual OGI in order to comply with NSPS OOOOa fugitive emissions requirements.



While we're asking questions, there are typically a whole lot more that go into determining the appropriate methodology for any specific situation…

What is the typical size and complexity of target sites?
New, multi-well production sites
Well pads of any size or age
Gathering compressor stations/pigging stations
Processing plants
A field of upstream and midstream oil and gas sites
Gathering pipelines
What is the spatial distribution of target sites?
Single facility
Cluster of closely-spaced sites
Widespread, loosely distributed sites
Linear (e.g., pipeline leaks)
What environmental and meteorological challenges apply?
Typical wind speed and direction
Topography
Vegetation structure (e.g., forested or grassland)
Weather (e.g., temperature, precipitation, dust, etc.)
Other local methane sources (e.g., landfills, cattle)
Who will maintain the equipment and how often are site visits required?
Will the site operator, regulator, or a third party maintain the equipment?
For systems located permanently at a site, do system objectives include a maximum frequency of site visits for maintenance or related activities such as instrument calibration?
Who will receive data from the system and what are their requirements?
Will the site operator, regulator, or a third party receive data from the systems?
How frequently does data need to be received?
What communication infrastructure is required to transmit data?
What is the tolerance towards false positives, false negatives, or other inaccurate data?
Does the system need to be specific to methane and/or measure other compounds?
Natural gas; Methane only; Isotopically-distinct methane (13C:12C or 2H:1H ratio); Total hydrocarbons; Volatile Organic Compounds; or Speciated individual compounds
What secondary objectives are mandatory for successful system performance?
Are there any regulatory requirements or barriers?



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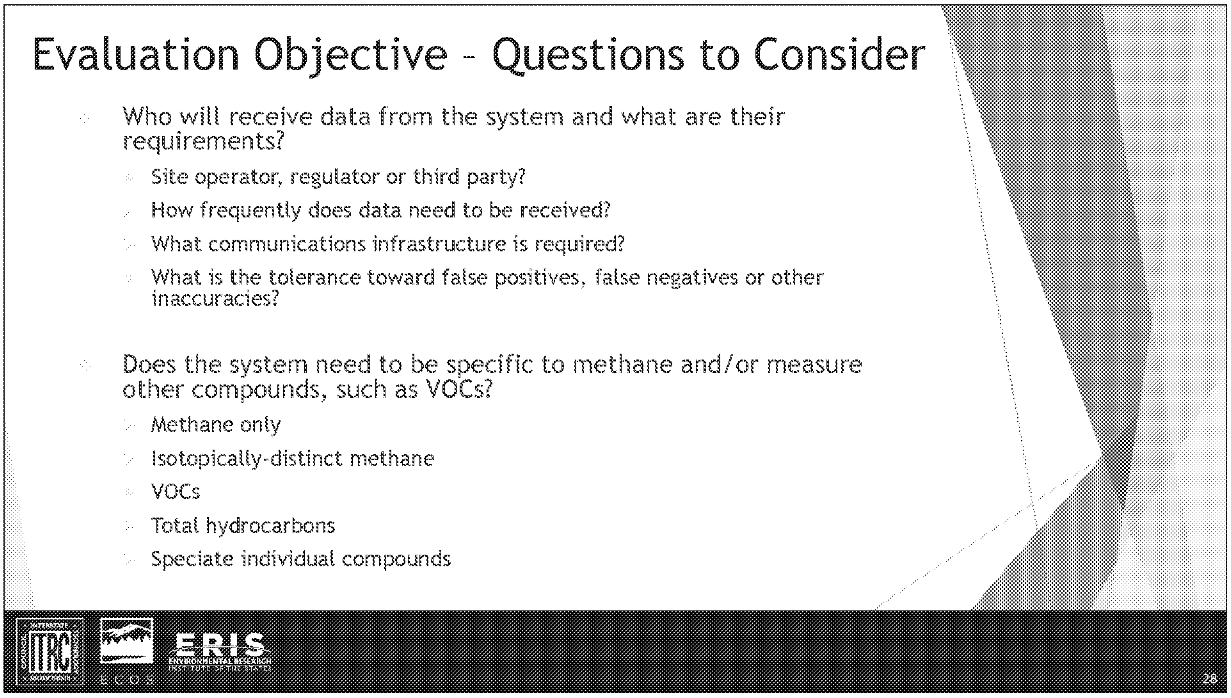

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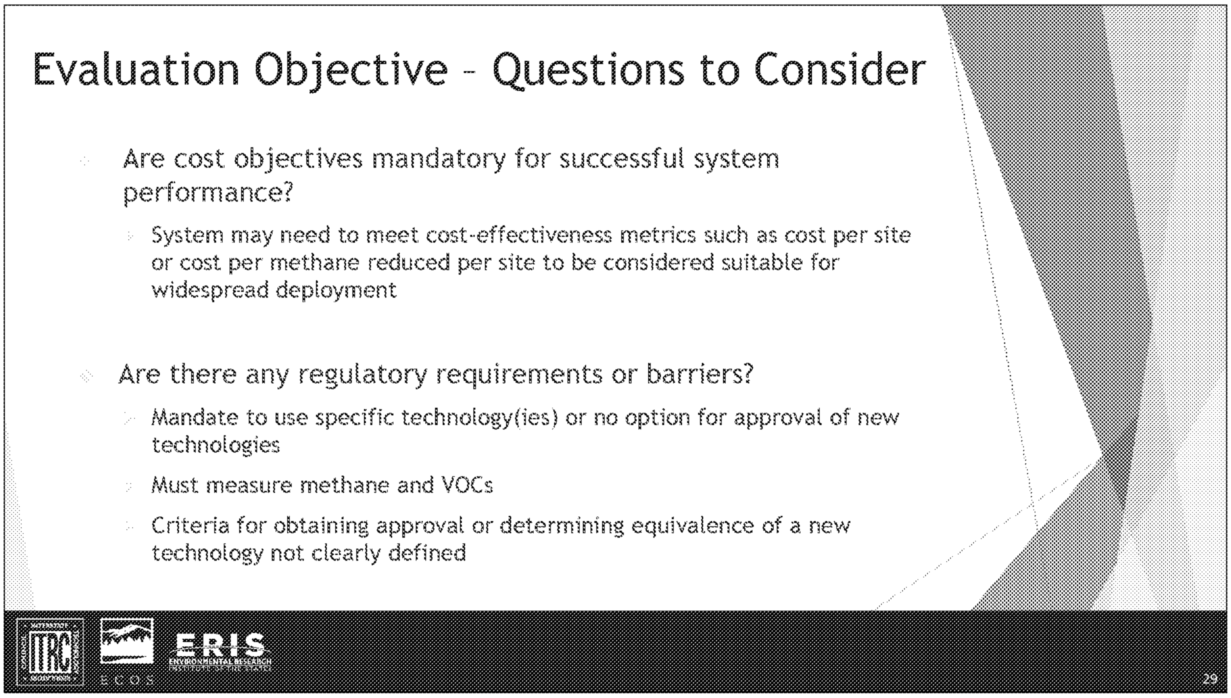

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Define Metric Types for Evaluation

- Most system objectives can be classified into one of three categories for performance defining metrics:
  1. Quantify Emission Reductions
  2. Identify Emission Source
  3. Emission Concentration I'm not sure I understand what an emission concentration is

- The objective should be expressed as a quantifiable, testable metric that describes the primary goals, target sites, and acceptable limitations of the system

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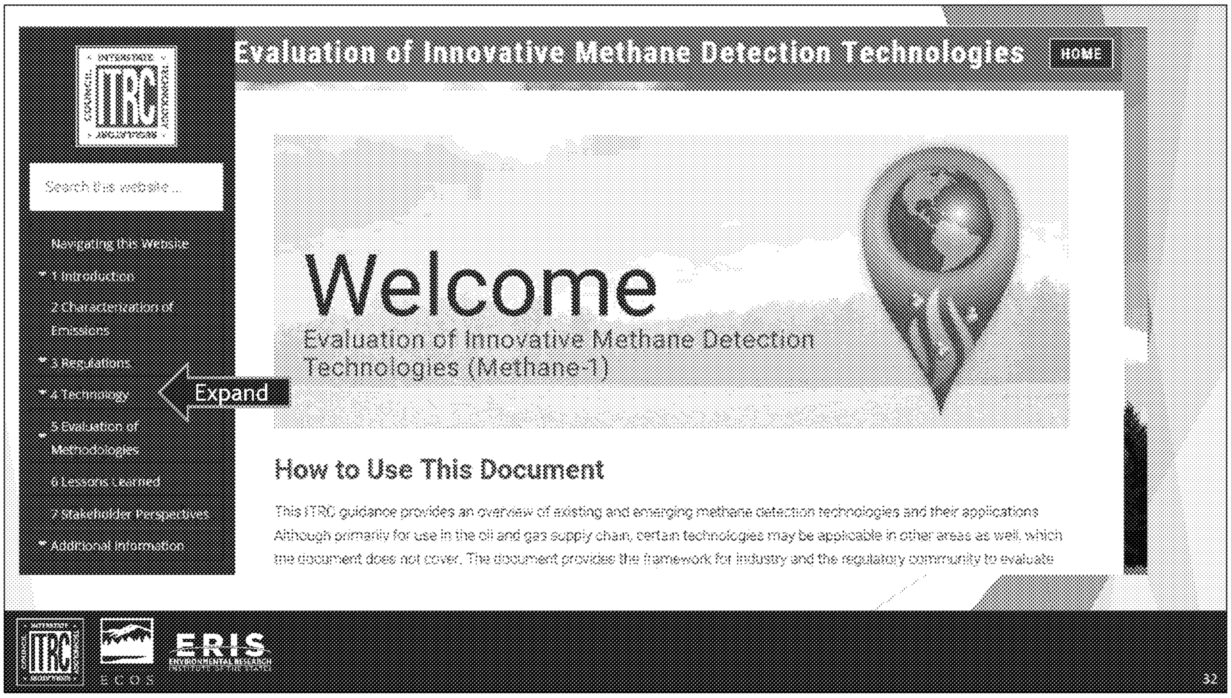
Metric Type Example 1:

Emission Reductions. The system will achieve equivalent or better emission reductions at compressor/gathering stations than prescribed regulatory technologies (OGI; Method 21) and work practices.

Equivalency is defined as percent of annual emissions mitigated at the company/basin-level. In addition to the system's ability to detect leaks, it must be evaluated as part of a work practice that includes the emissions threshold and time to repair detected leaks.

SERIES OF SCREENSHOTS OF WEB BASED DOCUMENT DRILLING DOWN...

Let's go back to our example objective statements and see how the document will help us choose the most appropriate technology...
What need to know up front. Use document to drill down



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Evaluation of Innovative Methane Detection Technologies (Methane-1)
How to Use This Document
This ITRC guidance provides an overview of existing and emerging methane detection technologies and their applications. Although primarily for use in the oil and gas supply chain, certain technologies may be applicable in other areas as well, which the document does not cover. The document provides the framework for industry and the regulatory community to evaluate
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4.1 Technology history and the classification scheme.

4.2 Each technology is discussed and a table with quick search information is available (table 5).

4.3 Here you will read about the questions to ask to determine which technologies fit your needs best.

Table 5. Summarizing Examples of Technology/Applications
Source: ITRC Methane Team.

Technology	Primary Data Type	Result Type	Detection Range (low to high) - Represents Typical Sensitivity of the Technology	Specificity to Methane/ Interference	Other Benefits	Measurement Temporal Resolution	Size (small, handheld, large)	Typical Deployment Method (walking, vehicle path, or fixed location)	Environmental Limitations (humidity, temperature, etc.)	Calibration Procedure	Maturity (developing, newly available, mature)	Miscellaneous
Pellistor (Catalytic Bead)	quantitative	quantitative (concentration)	500 ppm-5%	nonspecific/high	low cost, widely used or readily available	seconds	small	walking, fixed	humidity, temperature, contaminants	calibration gas; weeks to months	mature	See text
Metal Oxide Semi-conductor (MOS)	quantitative	quantitative (concentration)	50 ppm - 1%	nonspecific/high	low cost, widely used & readily available	seconds	small	walking, fixed	humidity, temperature, contaminants	calibration gas; frequent and self-zeroing	mature	See text
Flame Ionization Detector (FID)	quantitative	quantitative (concentration)	5 ppm (low)	nonspecific/high	widely used & readily available	seconds	handheld	walking, fixed	humidity, temperature, contaminants	calibration gas; frequent	mature	See text

Table 5 is a great resource…

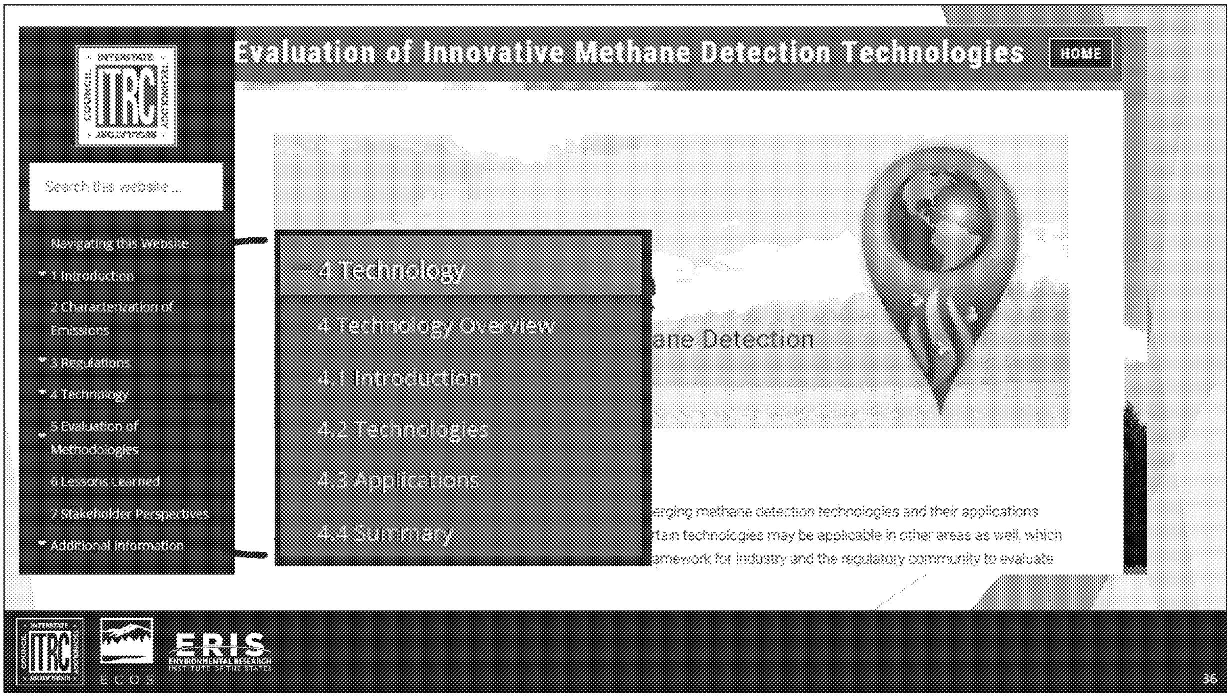
Metric Type Example 2:

If this is the DOE MONITOR criteria, you should state this in the example. Otherwise, identifying each 6 scf/hour souce has no meaning since, for example, this would be a normally designed emission rate for a pneumatic controller at a well pad and you should use a higher value.

Emission Source. The system will detect, locate, and quantify emission sources at well pads under a range of climate conditions for a specific geography.

Emission sources ≥ 6 scf/hour must be located within 1 meter spatial accuracy and their emission rate quantified to ±30% within 24 hours. Sources should be identified as intentional, unintentional, or offsite with less than a 5% error of misclassifying intentional or offsite sources as onsite, unintentional.

The system must perform successfully 80% of the annual hours with a maximum of 1 week to detect emissions.



Again, expand technology…

Metric Type Example 3:

Emission Concentration. The system will signal when fence line methane concentrations exceed an actionable level.

The system must have a 95% probability of signaling within 4 hours of elevated concentration during precipitation-free conditions of -20 to 120 ºF and <10 mph wind speed.

SERIES OF SCREENSHOTS OF WEB BASED DOCUMENT DRILLING DOWN...

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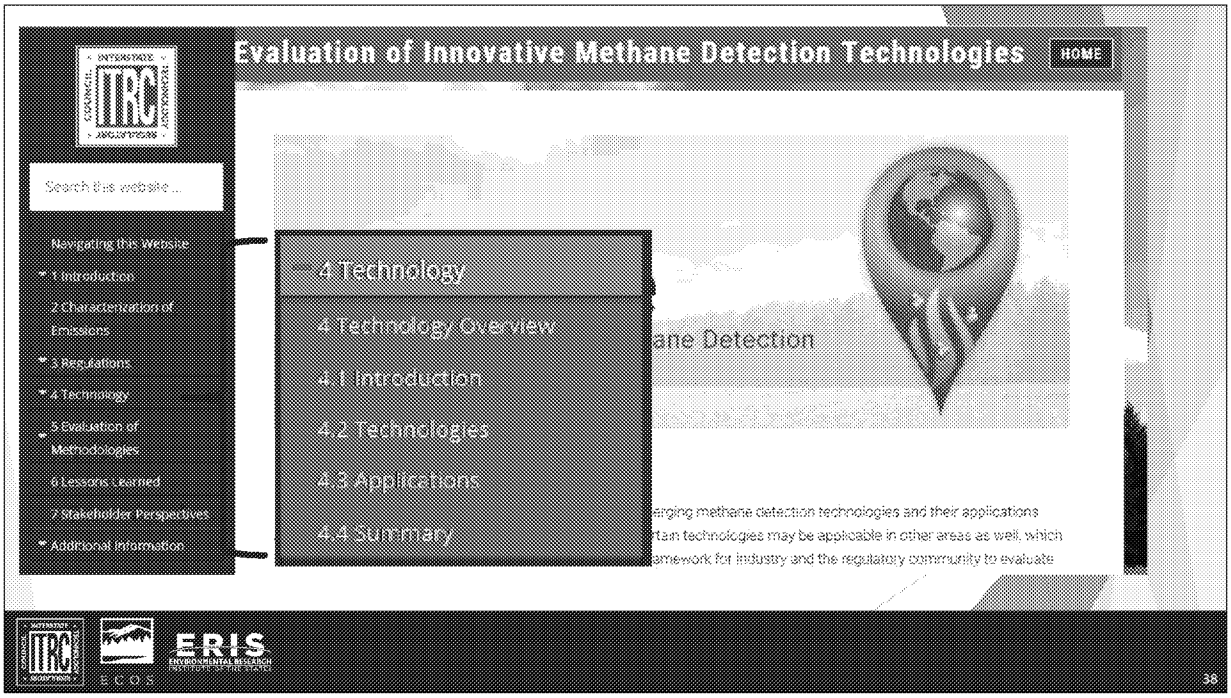
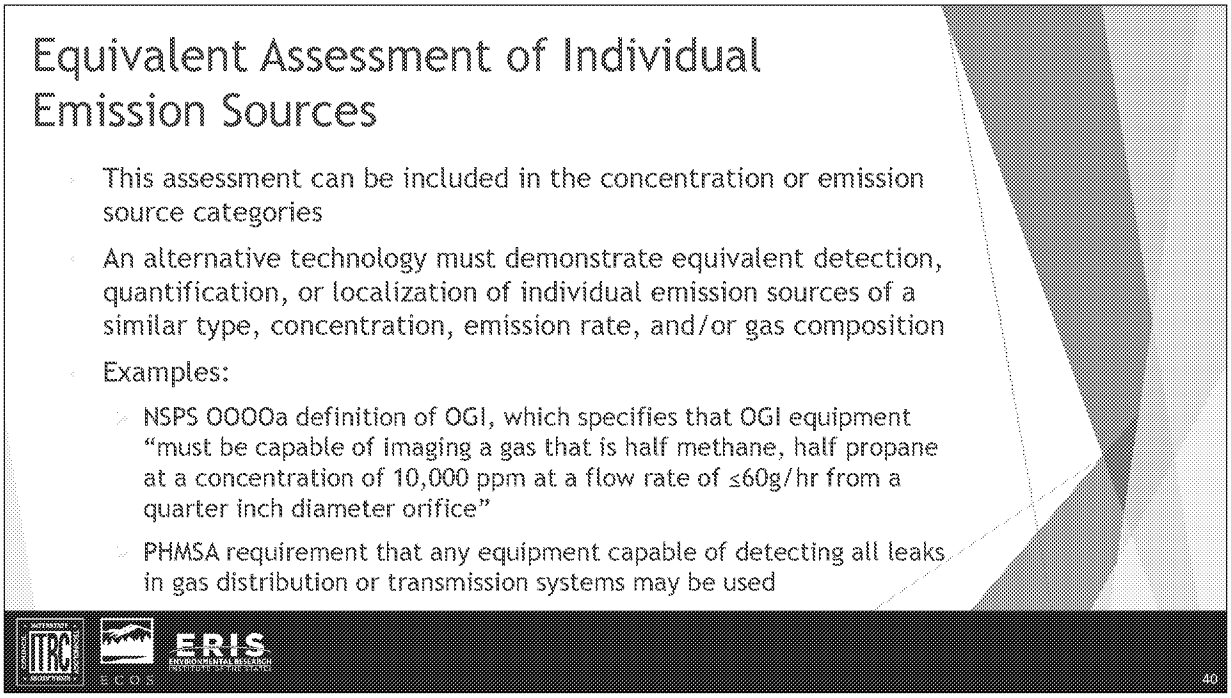
Let's go back to our example objective statements and see how the document will help us choose the most appropriate technology...
What need to know up front. Use document to drill down



Again, expand technology…

Technology Equivalency

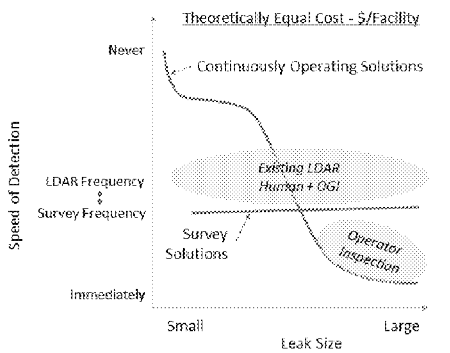
- Regulations may include an option for use of an approved alternative technology or program
- Data and information must be presented to demonstrate an alternative is equivalent or better than a default/prescribed technology at achieving target metrics
- Equivalency demonstration can be classified into two groups:
  1. Equivalent assessment of individual emission sources
  2. Equivalent reduction of aggregate emissions



NSPS OOOa OGI example is an assessment of a technology's ability to detect emissions from a well-defined source that can be evaluated with a controlled release under laboratory or field conditions.

Equivalent Reduction of Aggregate Emissions

- Demonstration of equivalent emission reductions at a specific spatiotemporal scale such as site's annual emissions
- More complex determination because a technology's minimum detection limit and response time affect its ability to reduce emissions



The best process is to develop a clear objective statement.
Express system objectives as quantifiable, testable statement that describes the primary goals, target sites, and acceptable limitations of the system.
Should include sufficient detail so any system that agrees with the full statement is considered compliant with the objectives.

Outline Protocols: Path 1

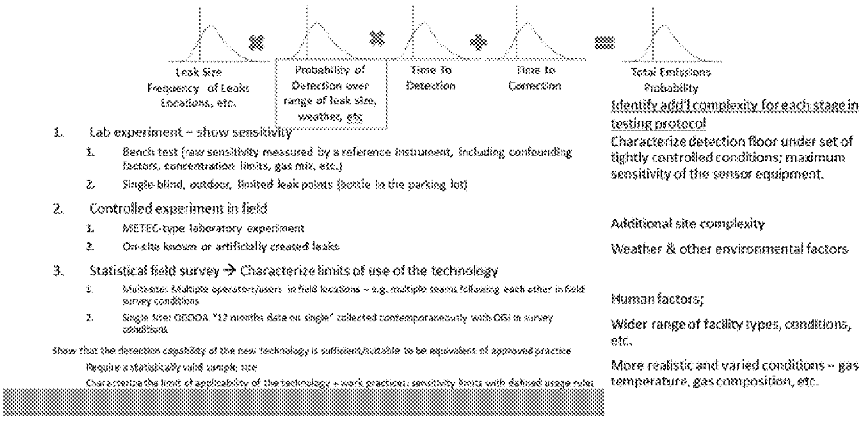


Figure 41. A conceptual model for evaluating source-based system objectives.

Source: Colorado State University.

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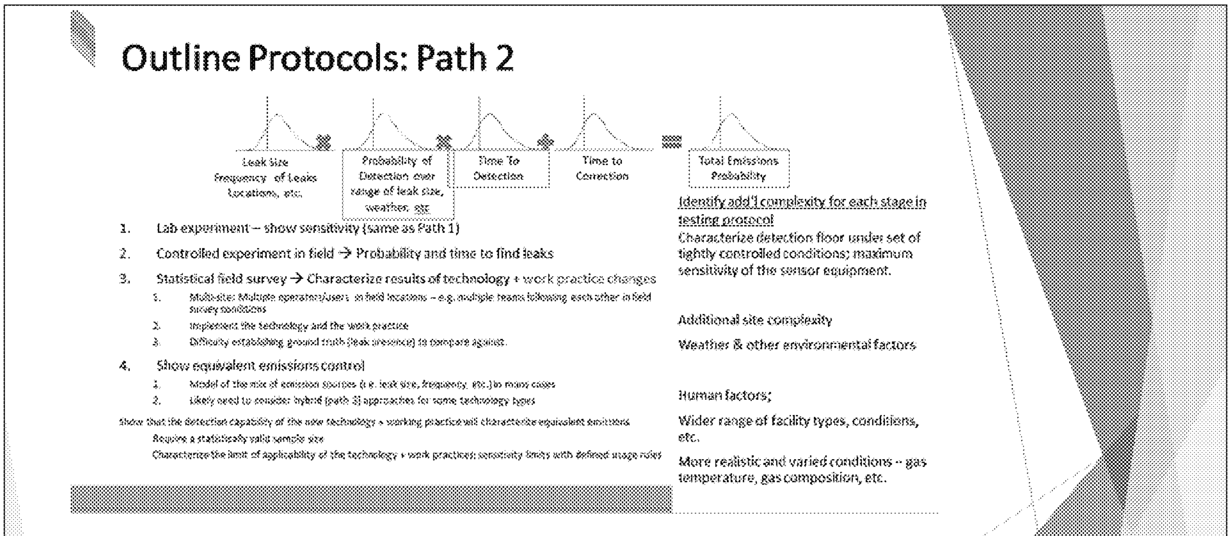

Figure 42. A conceptual model for evaluating reduction-based system objectives.

Source: Colorado State University.

Lessons Learned

- Methane detection technologies are moving to quantitative, continuously-recorded, data-intensive systems.
- Cost-benefit analyses, required for USEPA rule-making, will require a replacement methane detection technology to be "equivalent" to an existing system.
- Detection technology testing or evaluation protocols may have certain environmental limitations, which in turn may mean a new technology is approved only for certain applications or geographical areas
- There will be renewed opportunities for researchers, academics, industry, regulators, and interest groups to improve the methane detection technologies as well as the related regulations and the evaluation methodologies that link specific technologies to specific regulatory requirements.

Stakeholder Perspectives

- Stakeholder issues Identified:
  - Safety issues regarding proximity to operating facilities
  - Abandoned wells and/or lines
  - Oil and Gas Extraction Pipeline Safety
  - Adaptation of Detection Technologies Oil Wells Without Infrastructure to Capture Natural Gas
  - Underground Storage Facilities
  - Offshore Wells (and other issues outside the scope of this document)

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Check list of Stakeholder issues – what meaning oil and gas extraction (include info form text into notes). Also, prioritize in order of importance in list.

Bring together the examples – wrap up

1. Introduce ITRC
2. Provide Context for the Challenge & Solution
3. Characterization
4. Regulations
5. Technology
6. Methodology
7. Lessons Learned
8. Examples
9. Stakeholder Perspective

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Thank you!

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All Slides from here out are extras or may possibly be reincorporated back into the slide deck.

Characterization Nomenclature

Comparison of natural gas system characterization of Subpart W, GHG Inventory and this assessment

Source (GHG Inventory)	Natural Gas Systems (Annex 3.6)										
Stage (GHG Inventory)	Field Production					Processing	Transmission & Storage			Distribution	
Natural Gas Supply Chain	Drilling	Well Completion	Producing Wells	Gathering Lines	Gathering & Boosting Stations	Gas Processing Plant	Transmission Compressor Stations	Transmission Pipeline	Underground Storage	Distribution Mains/Services	Regulators & Meters
Segment (GHGRP-Subpart W)	Onshore Production			Onshore Gathering & Boosting		Onshore Natural Gas Processing	Onshore Transmission Compression	Onshore Natural Gas Transmission Pipeline	Underground Natural Gas Storage	Distribution	

Comparison of petroleum system characterization of Subpart W, GHG Inventory and this assessment

Source (GHG Inventory)	Petroleum Systems (Annex 3.5)					
Stage (GHG Inventory)	Production Field Operations				Crude Oil Transportation	Refining
Petroleum Supply Chain	Drilling	Well Completion	Producing Wells	Gathering Lines	Crude Oil to Refineries (not addressed here)	
Segment (GHGRP-Subpart W)	Onshore Production			Onshore Gathering & Boosting		

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Comment: Does this slide belong earlier in the presentation? (see Ona's revised version of tables). Nomenclature not used elsewhere in PPT?

Nomenclature used to describe the supply chain in natural gas and petroleum systems varies so first we will describe the organization provided in this chapter as compared to the US EPA Greenhouse Gas Inventory and the US EPA Greenhouse Reporting Program – subpart W. Tables 1 and 2 below show where each process falls into each of the systems of organization.

Evaluation of Methodologies

- Numerous sensor technologies and applications used to detect, locate, and/or quantify methane emissions, including:
  - stationary arrays or point sensors,
  - moving point or line sensors,
  - box flux estimation,
  - plume imaging,
  - long path sensing, and
  - tiered approaches integrating multiple systems
- Depending on target sites and stakeholder goals, several approaches may meet primary performance criteria though differ in other metrics (i.e., methane concentration detection limits)

Evaluation of Methodologies

- Develop evaluation protocols for assessing metrics. Each has a different set of approaches that can be used to evaluate systems objectives.
- *Concentration*
  - Laboratory testing
  - Field trial
- *Emission sources*
  - Laboratory testing
  - Field-based controlled releases
  - Field trial
- *Emission Reductions*
  - Field-based controlled releases and field trials
  - Modeling
  - Side-by-Side Testing
- Under controlled statistical field survey methods specific statistical data is derived

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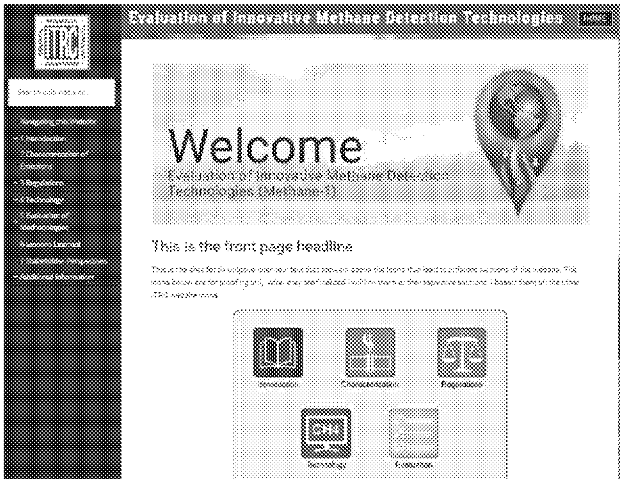
Example 1: Emission Reductions



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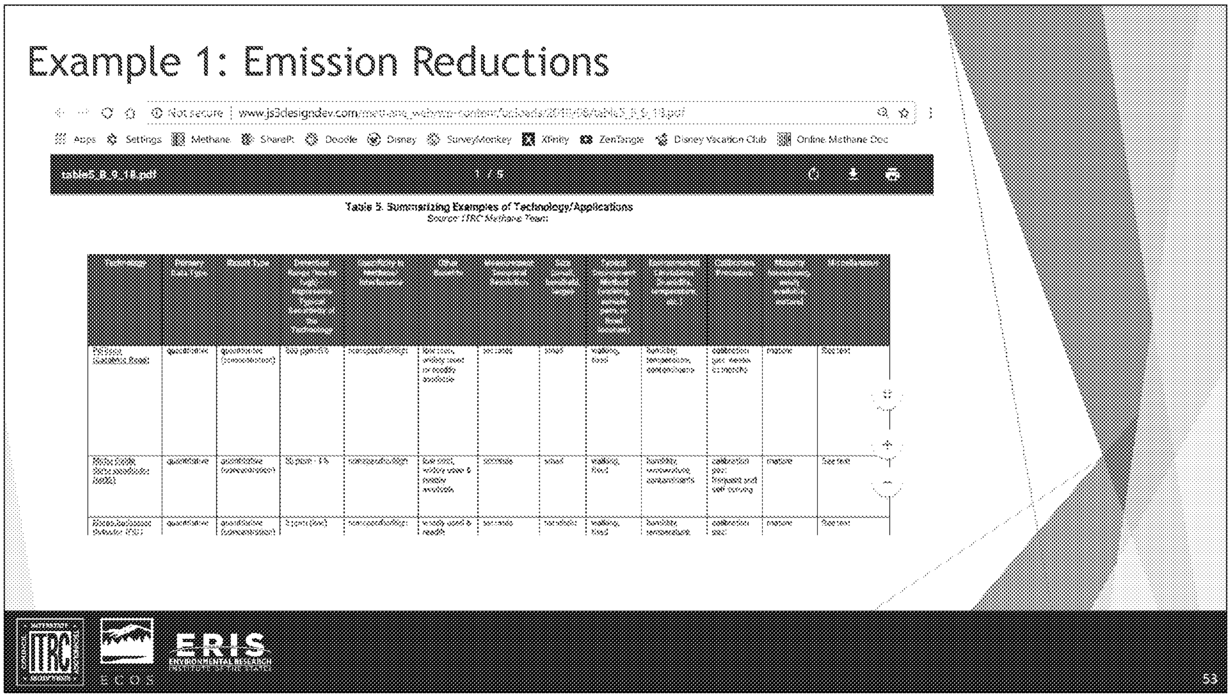

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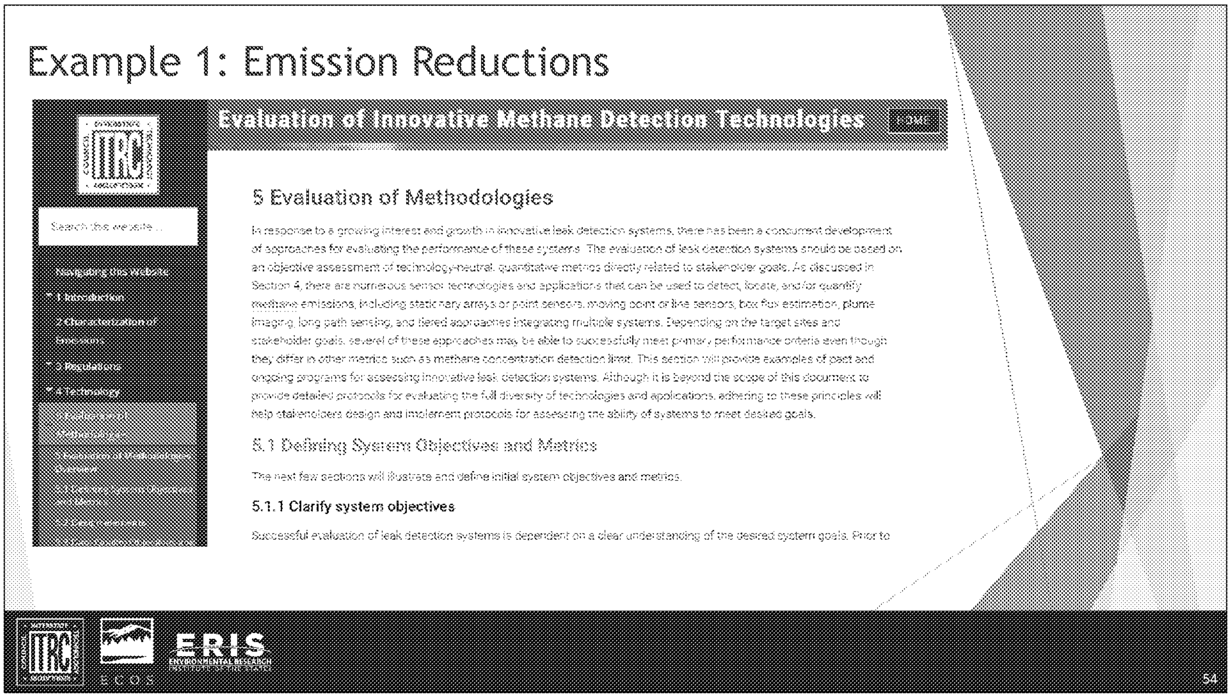

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Example 1: Emission Reductions

Screenshot of table 5 - narrow in on specific questions for example:

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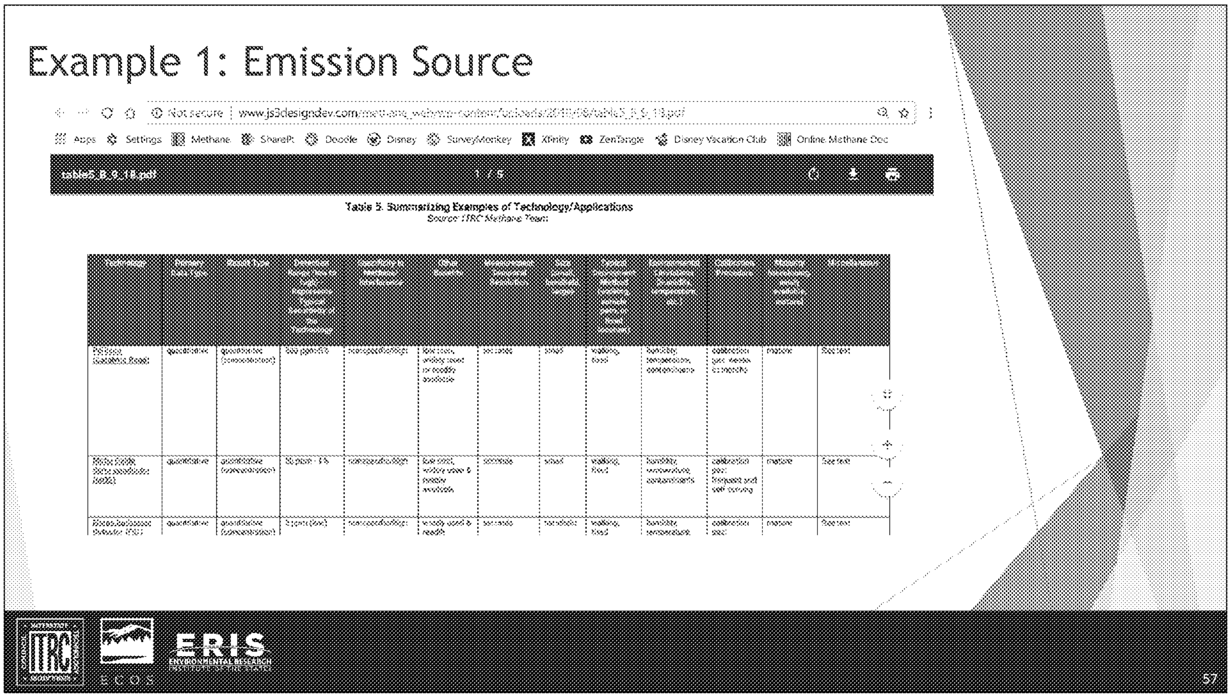

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Example 1: Emission Source

Screenshot of table 5 - narrow in on specific questions for example:

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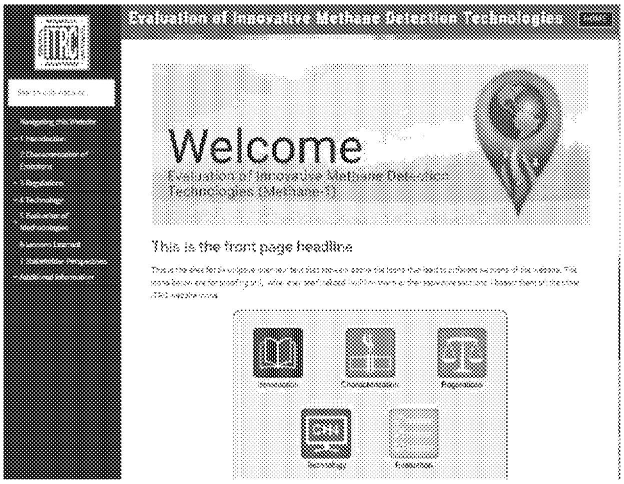
Example 1: Emission Concentration



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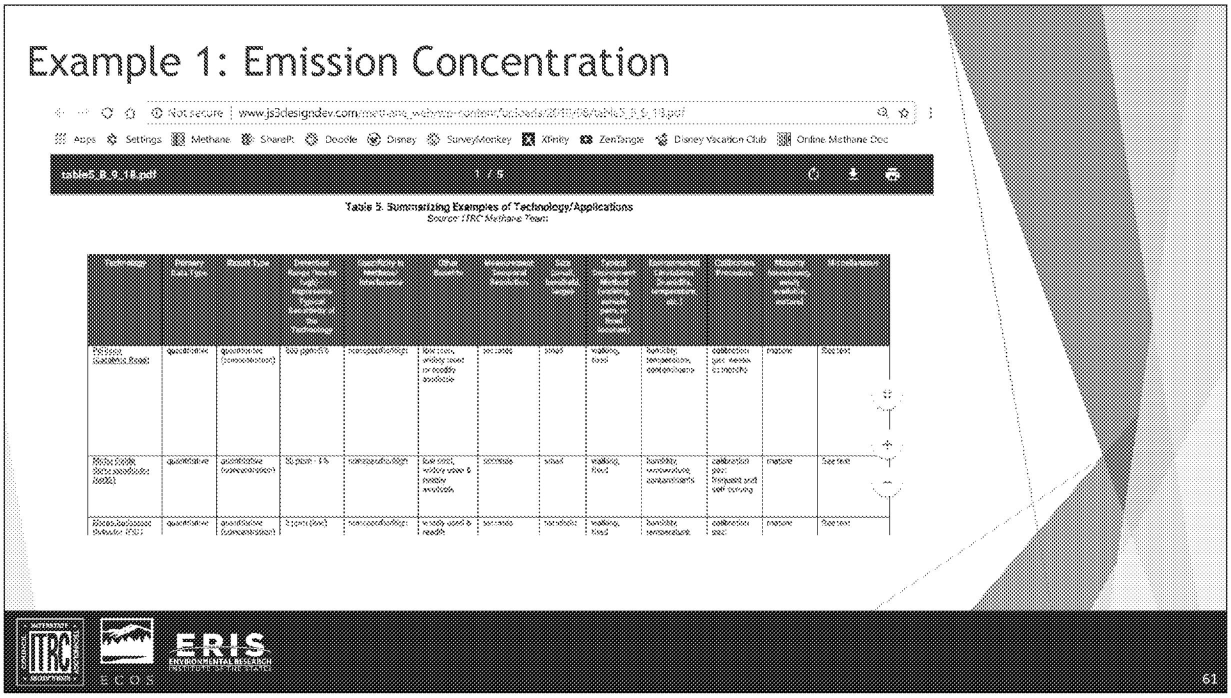

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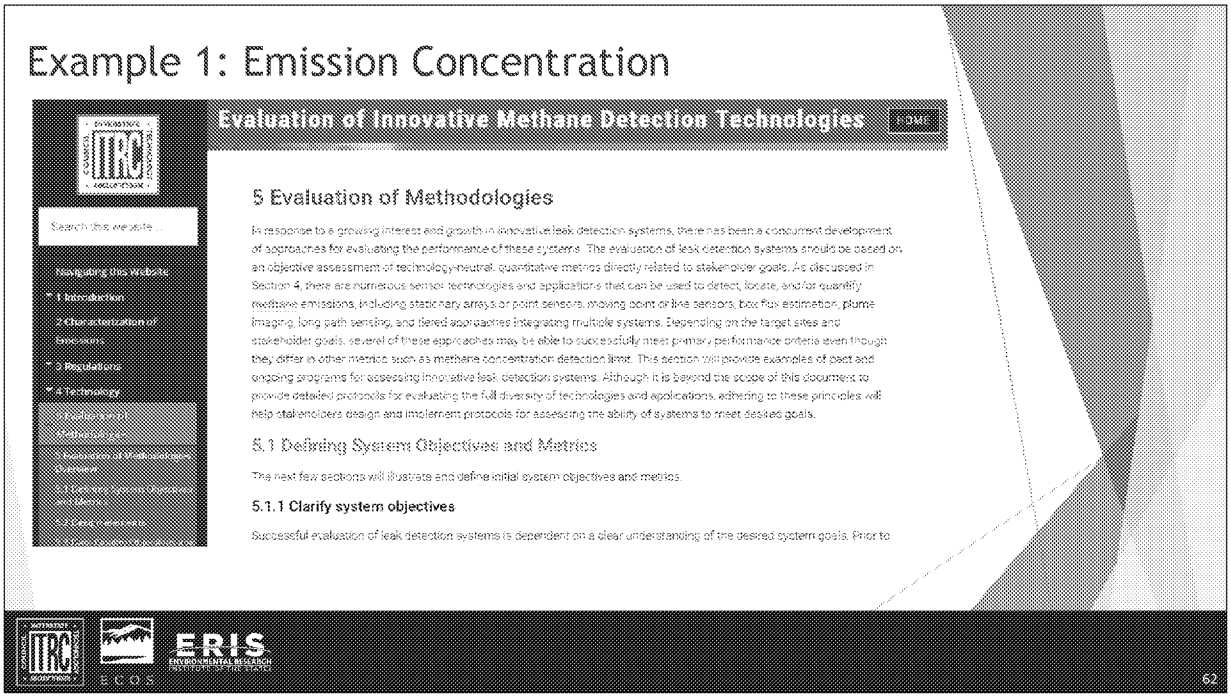

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Example 1: Emission Concentration

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